WATER SOFTENING AND DECOLORIZATION.

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The first six months of experience at the Grand Rapids Filtration Plant has demonstrated that no plant can be successfully run by "rule of thumb." Every water supply, especially if it be a surface water supply, carries some features that make the treatment of that water distinctive and set apart.

The Grand Rapids plant started full normal operations about November 1, 1912, drawing water from the Grand River. It being originally proposed to soften this water down to about 125 p. p. m. total hardness or what is generally known as the Lake Michigan standard and to reduce its color to 10 parts p. p. m. or less on the Platinum Cobat scale.

The Grand River drains an area of some two thousand square miles of sandy soil full of marshes and small lakes with but little clay ground, being largely adapted to orchards and small fruits. Moreover, the water is quite hard due to lime stone outcroppings.

When one steeps tea-leaves in water there results a color, an odor, and a taste. The distinctive problem at the Grand Rapids plant has proved the removal of the effects of the steeping of the meadows in water that subsequently reached the Grand River. The problem was rendered more difficult in that in addition to its color the water was hard and hard waters seem more difficult to decolorize than soft waters, provided there is an absence of clay.

In this respect it is interesting to compare the water supply of Columbus, Ohio, with that of Grand Rapids. The Grand Rapids supply, as noted above, is drawn from a sandy soil underlain with lime rock containing but little clay and with much vegetation, and spotted all over with lakes and ponds.

The Columbus supply is taken from the Scioto River which flows through a limestone region wholly clay and devoted to general farming operations with little or no swampy ground and but little sand.

This results in a water at Columbus whose turbidity and total hardness rises and falls through great ranges in very short periods of time—it being not unusual for the turbidity, for instance, to increase from 25 parts per million to 2200 p. p. m. in a period of eight hours following heavy rains over the watershed with a corresponding decrease in the hardness of the water.

These phenomena are due to the clay nature of the soil which lacks the "soaking up" and conserving capacity of lakes and sand and makes the Columbus problem largely one of coping with rapid changes of turbidity and hardness but with the color problem removed in that the presence of much clay in this water tends to absorb and therefore eliminate its color.

At Grand Rapids, on the other hand, the highest turbidity observed in the past six months has only been 135 p. p. m. with and average turbidity of 20 p. p. m. Moreover, due to the watershed being twice the area of the Scioto watershed, and due to the much sand and many small lakes which tend to absorb and conserve storm water, the river does not rise and fall so rapidly nor does it get very turbid, and because of the absence of much suspended clay—turbidity—the color as well as a slight marshy taste and odor which accompanies the color is much more persistent and difficult of removal. A secondary effect in rendering the color, odor and taste more difficult of removal is found in the opportunity for leaching out of the vegetable matter over the watershed offered by the conditions of which tend to hold back the water.

An interesting result of this condition is found in the summer time, when, following a general rain, the color and taste become more pronounced, due to the washing into the stream of pools formed as a result of low water, where this leaching effect has become exaggerated.

Ordinarily sulphate of alumina or iron are used as decoloring agents their efficiency depending on the fact that the reaction between the natural alkalinity of the water and the alumina or iron tends to break the latter up with the formation of alumina or iron hydrates whose physical properties of weight, insolubility, and the possession of a bulky gelatinous mass, tends to make them absorb and reduce color and the accompaying odor and taste.

In the case of very soft and highly colored waters such as are found in the East, it is necessary to supply a sufficient alkalinity to decompose the sulphates of alumina or iron in the form of lime hydrate or slacked "quick-lime" and iron has in almost every case been found to work more efficiently when accompanied with sufficient lime to produce a slight excess of hydrate alkalinity even though there be already present in the water sufficient bicarbonate alkalinity. Moreover, iron seems to exert more decolorizing and deodorizing power on some waters than alum as is claimed for its use at a plant recently completed at Fargo, North Dakota, though alum seems much more generally applicable. Where irón can be used it proves quite desirable due to the lesser expense of iron as compared to alum.

The total hardness of the water at Grand Rapids has averaged 217 p. p. m. with a maximum of 288 p. p. m. and a mimimun of 104 p. p. m. This has been accompanied by an average color of 32 p. p. m. and an average turbidity of 20 p. p. m.—the color ranging from 16 to 55 p. p. m. and the turbidity from 5 to 135 parts per million as minima and maxima. This total hardness is made up of the bicarbonates of calcium and magnesia averaging 188 p. p. m. accompanied by about 30 p. p. m. of sulphates and and average of 17 p. p. m. of magnesium for the past six months.

The first few days of operation showed that the amount of alum necessary to produce a water whose color was 10 p. p. m. or less was excessive—a water carrying a color of thirty to forty parts per million requiring three to four and one-half grains per gallon of alum to produce a water of the above requirements. Such treatment was not only expensive but so increased the sulphate or permanent hardness as to produce a very disagreeably hard water.

Meantime laboratory experiments indicated that the use of lime would not only soften the water but decolorize it as well and at less expense.

It is oftentimes a puzzle as to why "lime" is used to remove "lime." It is a basic chemical principle that an acid will combine with an alkali to produce a neutral body which is neither acid or alkaline. Calcium and magnesium salts are largely present in a water by virtue of the solvent action of the carbonic acid gas dissolved in the water and are therefore present in an acid condition. By the addition of an equivalent amount of an alkaline form of lime—calcium hydrate—there is produced a neutral body which is insoluble and if there should be five parts of such acid calcium or magnesium present in a water the addition of five parts of calcium hydrate—an alkaline form of lime—would precipitate out of the water 10 parts of lime which would contain the lime added as well as the lime present in the water. Moreover, magnesium so precipitated has much the same form physically as do the hydrates of alumina and iron and is available for the same uses—as coagulants to remove turbidity or color.

It was proposed therefore to utilize the magnesium in the Grand River water supply through the softening process as a decolorizing agent.

Ordinarily the softening processes can be carried to any point desired up to the full neutralization of all acid lime present. At the Grand Rapids plant, however, it was soon found that unless sufficient lime were added to completely neutralize all bicarbonate or acid alkalinity that the magnesium was not precipitated in a form to be sufficiently available for decolorizing purposes and therefore we were compelled either to soften the water to a point much lower than the 120 or 125 parts per million desired or else operate at greater unit cost in that a partial softening of the water made it necessary to use two to three grains of alum in addition to the lime to produce a satisfactory color.

On the other hand, by the addition of lime sufficient for the full neutralization of the bicarbonates present, it was found that we could produce a water whose color was 10 or less and whose total hardness ranged from 88 to 100 parts per million for the past six months. By so doing we were able to reduce the alum required to an amount as low as one-fourth grain per gallon, its function being largely to help carry down the fine crystals of calcium carbonate formed in the softening process.

From the standpoint of the consumer, this was excellent, in that the water so produced was soft enough to lather freely in the cold and without the formation of the "scums" that are so disagreeably characteristic of hard water as well as a water whose color was no longer noticeable. In addition this later method of treatment enables us to operate at a much less cost per million gallons than by the use of alum.

The use of alum, then, offered as an advantage color removal alone and as disadvantages increased cost of operation and increased hardness of the water produced.

The use of lime offered as advantages the reduction of both hardness and color at greatly reduced cost as compared with alum, the disadvantages from the operators' standpoint being that once the people of any community become accustomed to a very soft water they also become sensitive to any upward changes of hardness and are therefore liable to notice and object to any increases in hardness later on.

So far as we have been able to study and observe our problem this method of treatment with lime has proved most efficient and economical for all classes of waters the seasons have brought to our plant. Whether the color drop to as low as 20 p. p. m. as in the hard waters of the summer time or rise to 60 or 70 p. p. m. following the spring floods it requires excessive amounts of alum for its removal, and lime, therefore, proves most efficient save for these short periods when the total hardness gets as low as 100 to 120 p. p. m. with the magnesium in the water falling off to 10 to 15 p. p. m., at which time alum must of necessity be used.

The average reduction of magnesium in the filtered water as compared to the river water following such treatment as the above has been 25 per cent.